Bathymetric and Subbottom Survey
at the Cornfield Shoals Disposal Site,
July 8, 1994

Disposal Area Monitoring System DAMOS

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13. ABSTRACT

Over 100,000 m3 of mechanically dredged fine-grained material was released at a taut-wire moored buoy at the Cornfield Shoals Disposal Site (CSDS) during disposal operations in 1991 and 1992. Despite the fact that this is a high energy dispersive disposal site, the fine-grained dredged material did form a mound that was detected during bathymetric and REMOTS® surveys in 1992. Over time, active bed transport of ambient sediment at the site has produced areas of accumulation and areas of loss. Active bed transport also may have caused the fine-grained deposit to be covered by sand. If sand has been transported over the fine-grained material, the usefulness of REMOTS® sediment-profile photographs in mapping the dredged material deposit is limited. The sand makes it difficult for the camera prism to penetrate to the depth of the dredged material. Due to the limitation of the REMOTS® method, a swept frequency subbottom profile survey was conducted at CSDS in 1994 to map the extent of this fine-grained deposit.

The 1994 bathymetric survey detected minimal accumulation (25 cm) over the disposal mound since 1992. The 1994 bathymetry also detected accumulations over a broad area southeast of the disposal mound. At the disposal location, the subbottom profile survey detected an acoustic horizon at 1 m below the seafloor. Southeast of the disposal location, the subbottom record identified a sand wave field. Taken together, the results of the bathymetry and subbottom surveys mapped evidence of fine-grained dredged material accumulation at CSDS as well as evidence of active bed transport of ambient sand.

Fine-grained material was released at CSDS to examine whether this dispersive site was suitable for the disposal of cohesive, mechanically dredged silts and clays. The survey results suggest two approaches to the management of fine-grained dredged material at CSDS. Fine-grained material is likely to accumulate at CSDS if it is disposed at a taut-wire moored buoy. This management approach would allow close management of the material, but it may reduce site capacity. Fine-grained material may not accumulate if it is disposed in relatively small volumes at numerous discrete locations (e.g., LORAN-C coordinates). If the release of fine-grained dredged material is managed this way, resuspension and dispersal may prevent mound formation and retain site capacity.

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EXECUTIVE SUMMARY

Over 100,000 m^3 of mechanically dredged fine-grained material was released at a taut-wire moored buoy at the Cornfield Shoals Disposal Site (CSDS) during disposal operations in 1991 and 1992. Despite the fact that this is a high energy dispersive disposal site, the fine-grained dredged material did form a mound that was detected during bathymetric and REMOTS® surveys in 1992. Over time, active bed transport of ambient sediment at the site has produced areas of accumulation and areas of loss. Active bed transport also may have caused the fine-grained deposit to be covered by sand. If sand has been transported over the fine-grained material, the usefulness of REMOTS® sediment-profile photographs in mapping the dredged material deposit is limited. The sand makes it difficult for the camera prism to penetrate to the depth of the dredged material. Due to the limitation of the REMOTS® method, a swept frequency subbottom profile survey was conducted at CSDS in 1994 to map the extent of this fine-grained deposit.

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Fine-grained material was released at CSDS to examine whether this dispersive site was suitable for the disposal of cohesive, mechanically dredged silts and clays. The survey results suggest two approaches to the management of fine-grained dredged material at CSDS. Fine-grained material is likely to accumulate at CSDS if it is disposed at a taut-wire moored buoy. This management approach would allow close management of the material, but it may reduce site capacity. Fine-grained material may not accumulate if it is disposed in relatively small volumes at numerous discrete locations (e.g., LORAN-C coordinates). If the release of fine-grained dredged material is managed this way, resuspension and dispersal may prevent mound formation and retain site capacity.

1.0 INTRODUCTION

The Cornfield Shoals Disposal Site (CSDS), a dredged material disposal site managed by the US Army Corps of Engineers, New England Division, as part of the Disposal Area Monitoring System (DAMOS) Program, has been used for the disposal of dredged material since 1978. The site is located 6.12 km south of Cornfield Point in Old Saybrook, CT (Figure 1-1). Because the site is exposed to strong tidal currents, dredged material released at the site is expected to be dispersed following disposal (Bohlen et al. 1992). It is the only open water disposal site managed by NED as a dispersive disposal site. Although it is not detrimental for material to remain on site, any dredged material released there must have no adverse impact if it is to be transported away from the area. All other DAMOS disposal sites are containment sites where it is desirable for the dredged material to remain on site in a stable deposit.

Evidence of active bed transport in a 1990 survey at CSDS prompted concern by the National Marine Fisheries Service and the Connecticut Department of Environmental Management about possible impacts of suspended sediment transport on shellfish beds north of CSDS. In 1991 and 1992, the site was monitored during the disposal of sands from the Connecticut River (50,800 m^3) and fine-grained material from North Cove (105,479 m^3). This was the first time a taut-wire moored buoy was deployed at the site. This study determined that, although the area had a high degree of active bed transport, some of the fine-grained material formed a detectable deposit at the disposal location and remained on site for a period of at least eight months (Wiley 1996a). These results suggested that CSDS might require management information regarding the longer term fate of sediments deposited at the site.

The deposit of fine-grained material was documented in REMOTS® sediment-profile photographs and in changes to the bathymetry. The REMOTS® photographs, in addition to detecting the presence of the fine-grained dredged material, also documented a layer of sand that had moved over the deposit since its deposition. Because the sand limited the penetration depth of the REMOTS® camera, it was unclear how extensive the fine-grained deposit beneath the sand layer was. At the conclusion of the study in August 1992, the deposit had been in place for four months, and the fate of the fine-grained deposit over a longer time frame was unknown (Wiley 1996b).

The disposal of fine-grained dredged material onto a sandy seafloor provides a layering of different grain size and sediment densities that may allow for the detection of the boundary between fine-grained dredged material and ambient sand by swept-frequency subbottom seismic profiling. Subbottom seismic profiling determines changes in sediment acoustic impedance (the product of the sediment's density and the speed of sound). The

contrast in grain size and density between the sand and the mud should result in a change in acoustic impedance and therefore a visible boundary or horizon on the subbottom records.

The current CSDS survey, conducted on July 8, 1994, employed swept-frequency subbottom technology to map the extent of the fine-grained deposit. This survey was extended 300 m west of the 1991/1992 survey boundaries to try to detect deposits caused by the east-west transport documented in previous physical oceanographic studies of the area (Bohlen et al. 1992, NUSC 1979). A bathymetric survey was run concurrent with the subbottom survey. By comparing the 1994 results to previous surveys, the bathymetric results documented areas of erosion and accumulation over the last two years. The detection of an acoustic reflector under approximately one meter of material at the location used for the disposal of fine-grained North Cove dredged material confirmed the conclusion of previous REMOTS® and bathymetric surveys. Detection of a fine-grained dredged material deposit at a taut-wire moored buoy so many months after disposal is further evidence that the deposit is stable.

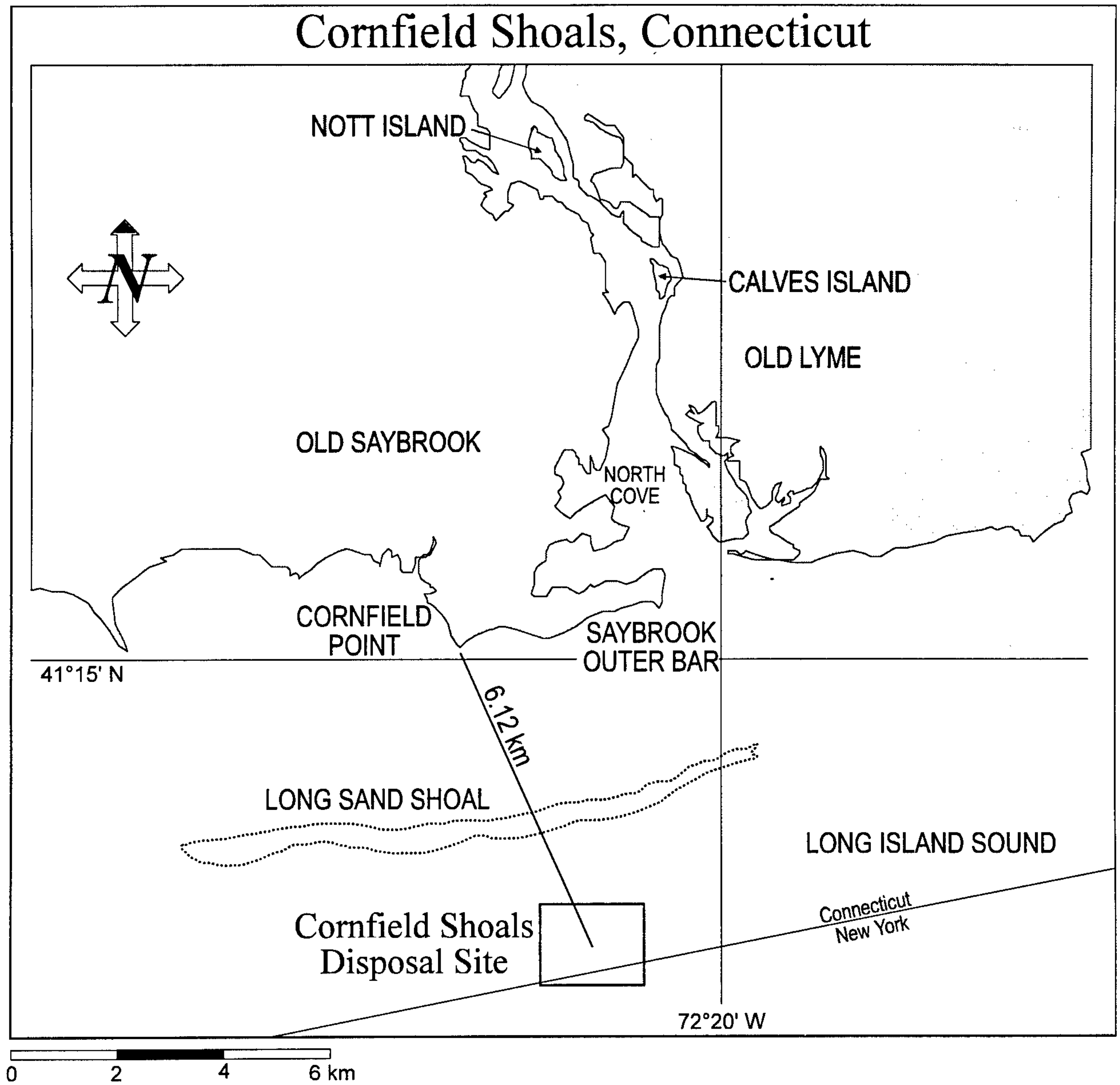

Figure 1-1. Location of Cornfield Shoals Disposal Site (CSDS)

2.0 METHODS

After completion of a survey at Central Long Island Sound Disposal Site (Morris 1994), the survey team devoted a day to collect additional bathymetric and subbottom profile data at CSDS to confirm the presence of the fine-grained dredged material deposit, measure its thickness, and determine its stability over two years. The combination of bathymetric and subbottom profiling techniques has been particularly effective when used to map distinctive layers of dredged material deposits in the New York Mud Dump and in Long Island Sound.

The July 8, 1994 survey at CSDS was set up over a 1000 m × 750 m grid (29 lanes at 25 m lane spacing) centered on 41°12.775' N, 72°21.857' W and oriented east and west. Throughout the survey, both the bathymetric and subbottom profilers were operated simultaneously along each survey lane. The 208 kHz transducer for the bathymetric survey was attached to the side of the vessel. The acoustic transducers of the subbottom system were mounted on a towfish and towed 5 m below the water surface and approximately 15 m behind the vessel. After completing 20 lanes, the survey was interrupted by an electrical storm, and survey operations, which were limited to one day, were suspended.

2.1 Bathymetry

The SAIC Integrated Navigation and Data Acquisition System (INDAS) provided the precision navigation required for all field operations. This system uses a Hewlett-Packard 9920® series computer to collect position, depth, and time data for later analysis, and to provide real-time navigation. A Del Norte Trisponder® System provided positioning to an accuracy of ±3 m. Shore stations were established in Connecticut at known benchmarks at Cornfield Point (41°15.790' N, 72°23.040' W) and Lynde Point Light (41°16.290' N, 72°20.590' W) in Old Saybrook, Connecticut. DAMOS Contribution No. 60 (SAIC 1989) contains a detailed description of INDAS and its operation.

An ODOM DF3200 Echotrac® Survey Recorder with a narrow-beam 208 kHz transducer recorded depth to a resolution of 3.0 cm (0.1 ft) as described in DAMOS Contribution No. 48 (SAIC 1985). Depth values transmitted to the computer were adjusted for speed of sound and transducer depth. Before starting the bathymetric survey, a SeaBird Instruments, Inc. SEACAT SBA 19-01 conductivity-temperature-depth profiler (CTD) was used to calculate a sound velocity profile. During analysis, all depth values were converted to Mean Low Water (MLW) after compensating for vessel draft and tidal fluctuations. Position and depth were also checked to identify and eliminate any outlying

values before producing an accurate contour plot. Analysis of the bathymetric data was conducted using the Hydrographic Data Analysis System (HDAS).

2.2 Subbottom Survey

An X-Star Model SB-216 Full Spectrum Digital Subbottom Profiler, manufactured by Precision Signal, Inc., was used to acquire subbottom profile data at CSDS. Subbottom seismic profiling is a standard technique for determining changes in acoustic impedance below the sediment-water interface. Acoustic impedance is the product of the density of the layer and the speed of sound in the layer. The depth of penetration and degree of resolution are dependent on the frequency and pulse width of the seismic signal, and the characteristics of the penetrated material.

The narrow beam (13°) transducer of the X-Star system was mounted in a towfish body that trailed approximately 15 meters behind the survey vessel. During the subbottom survey, the X-Star profiler generated a frequency-modulated pulse that was swept over an acoustic range from 2 to 20 kHz. The pulse rate was kept at 6 pulses per second for optimum performance of the output devices. At 6 pulses per second, while traveling at the average vessel speed of 4-5 knots, a subbottom measurement was acquired every 34-43 cm along the vessel track.

The amplified return signal of the X-Star transducers was sent through an A/D converter to an onboard Sun Sparc II Workstation for data display and archive. Data were displayed on the screen in real time and ported to an Alden thermal printer for a hard copy record. Data were also stored on Exabyte tapes for further processing on shore.

3.0 RESULTS

3.1 Bathymetry

The July 1994 survey grid extended approximately 300 m west of the boundary of the surveys conducted in 1991 and 1992. Extending the boundary allowed the bathymetry to show a continuation of the slope in the southern half of the survey and a depression trending northwest in the northwest corner of the survey (Figure 3-1). Decreased depth at the disposal location, first observed in May 1992 (Wiley 1996a), was visible during the July 1994 survey as well.

To compare the July 1994 data with the 1992 data, all results were corrected to areas in the May 1992 survey unaffected by disposal (an accepted method for normalizing to a benchmark survey). Comparing the May 1992, August 1992, and July 1994 surveys shows that the general bathymetry at the site has changed very little (Figure 3-2). The shallowest point is at the north border of the grid; the disposal location is marked by perturbations to the contours on the slope; and the deepest area is 55 m at the southern border.

Between July 1994 and May 1992, the greatest changes in depth were 25 cm (Figure 3-3). Material appears to have accumulated along the slopes in the northwest and southeast corners of the survey and at the disposal location. The accumulation at the disposal location occurred where the July 1994 contours broadened compared to the May 1992 survey. Areas of apparent loss between May 1992 and July 1994 are mostly very small areas associated with surveying across a steep slope (SAIC 1993).

3.2 Subbottom Survey

The subbottom records from the X-Star survey at CSDS clearly showed the dredged material deposit (dredged material reflector above the ambient bottom reflector) at the disposal location. The X-Star records also provided a detailed record of surface features such as the disposal mound and sand waves that are below the resolution of the bathymetric survey. Because the survey was run with the tidal currents (west to east) on the odd numbered lanes and against the current on the even numbered lanes, records were clearer on the even numbered lanes where data was collected on a finer scale.

The ambient surface reflector was seen clearly below the dredged material reflector in lanes 7, 8, and 9 (Figure 3-4). The maximum height of the disposal mound, based on the depth to ambient reflector, was 1 m. North and south of the mound, where the deposit was less than approximately 1 m in height (lanes 4, 6, 10, and 12), the X-Star did not

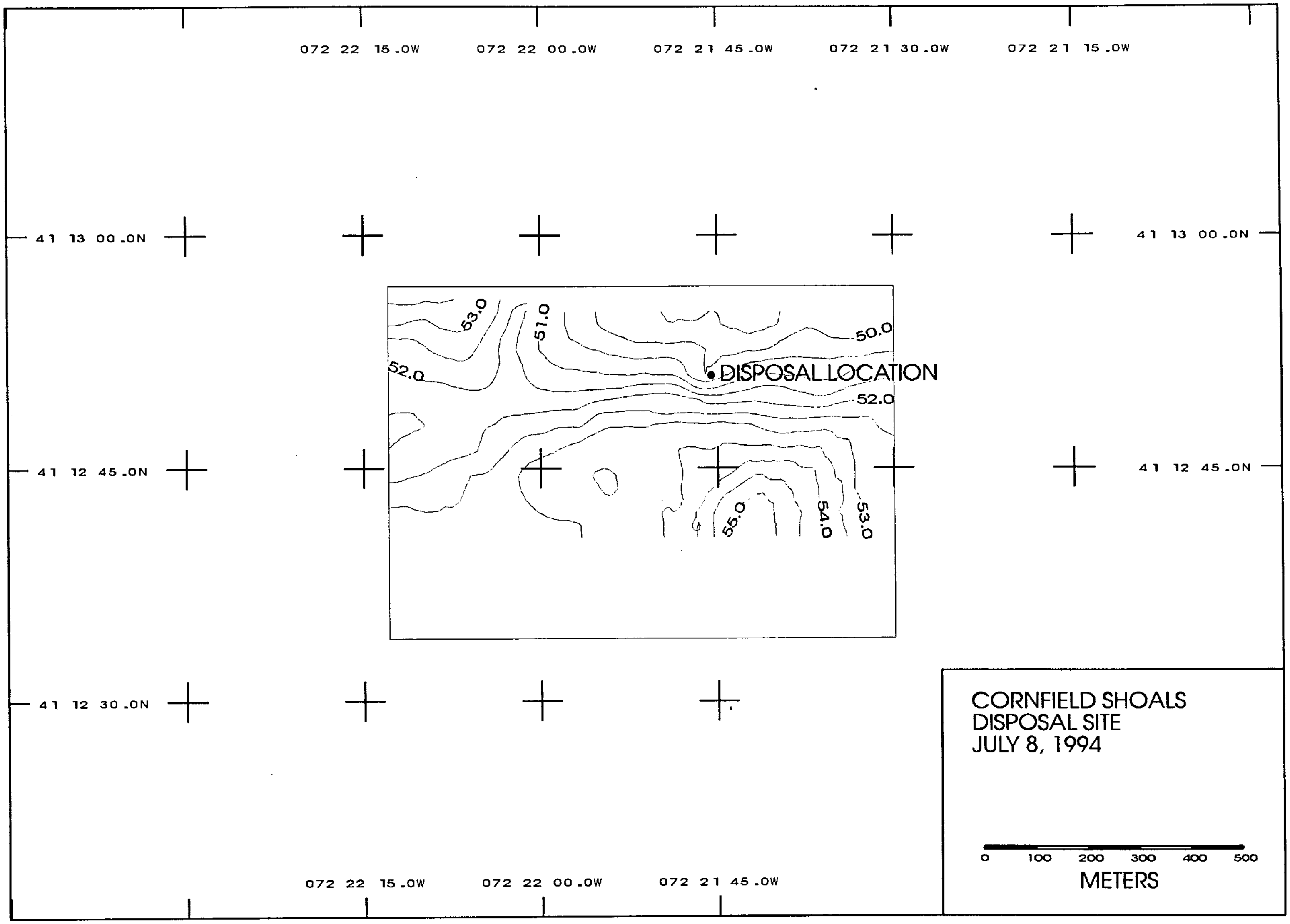

Figure 3-1. Bathymetry at CSDS, July 1994, uncorrected (depth in meters)

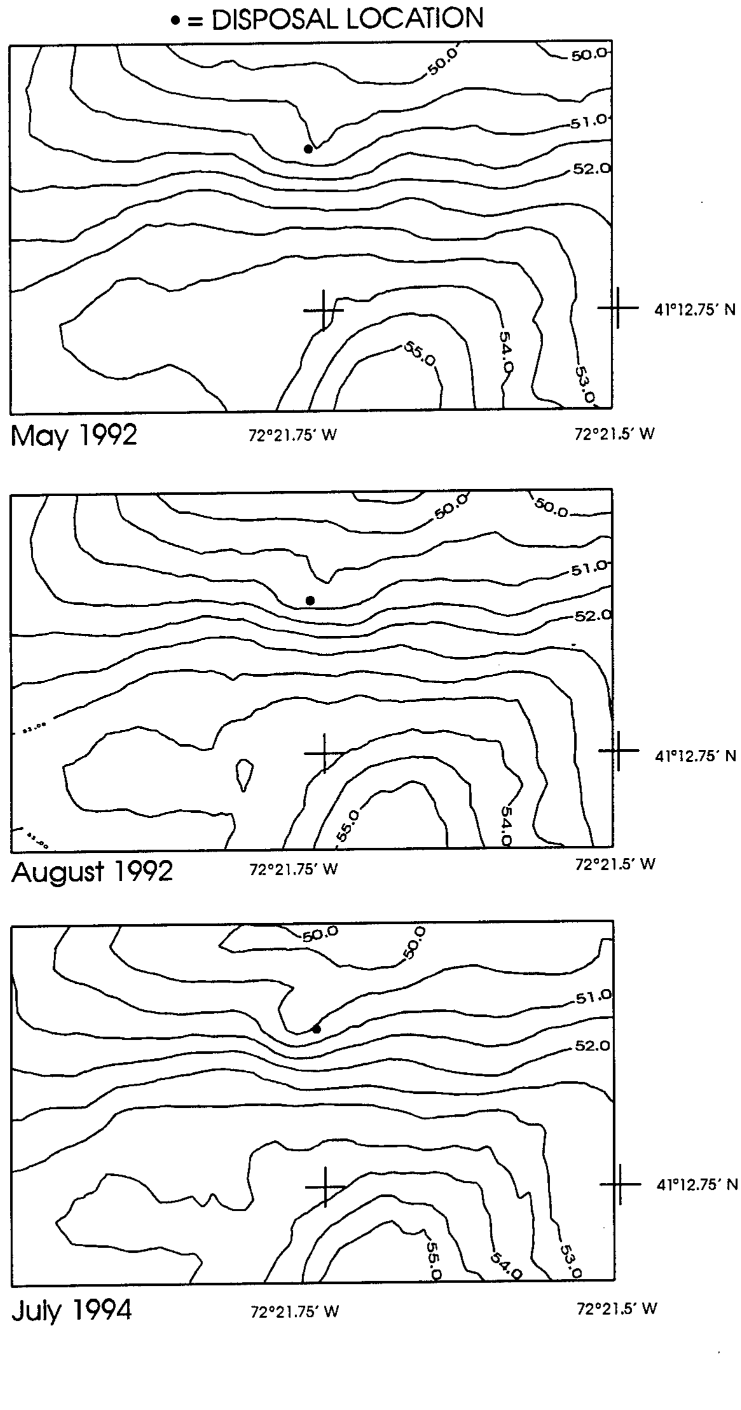

Figure 3-2. CSDS bathymetry, May 1992, August 1992, and July 1994 (depth in meters)

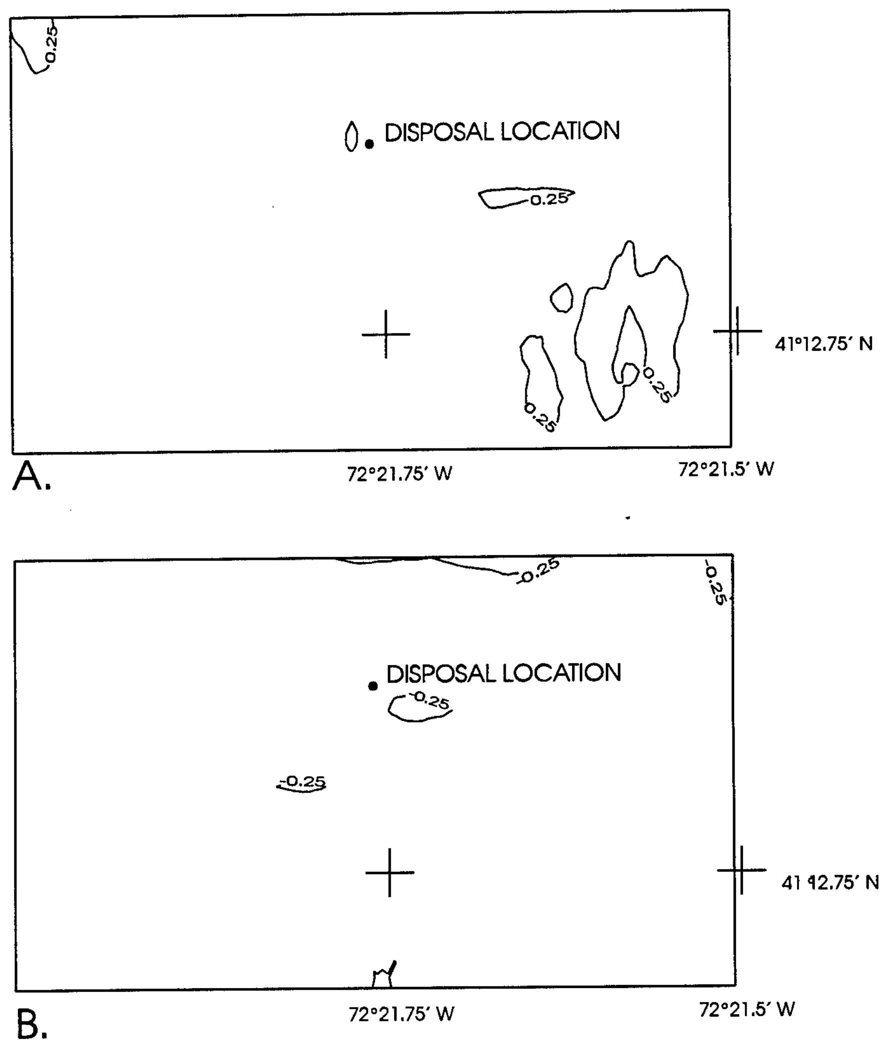

Figure 3-3. Areas of accumulation and loss between May 1992 and July 1994 at CSDS (contours in meters)

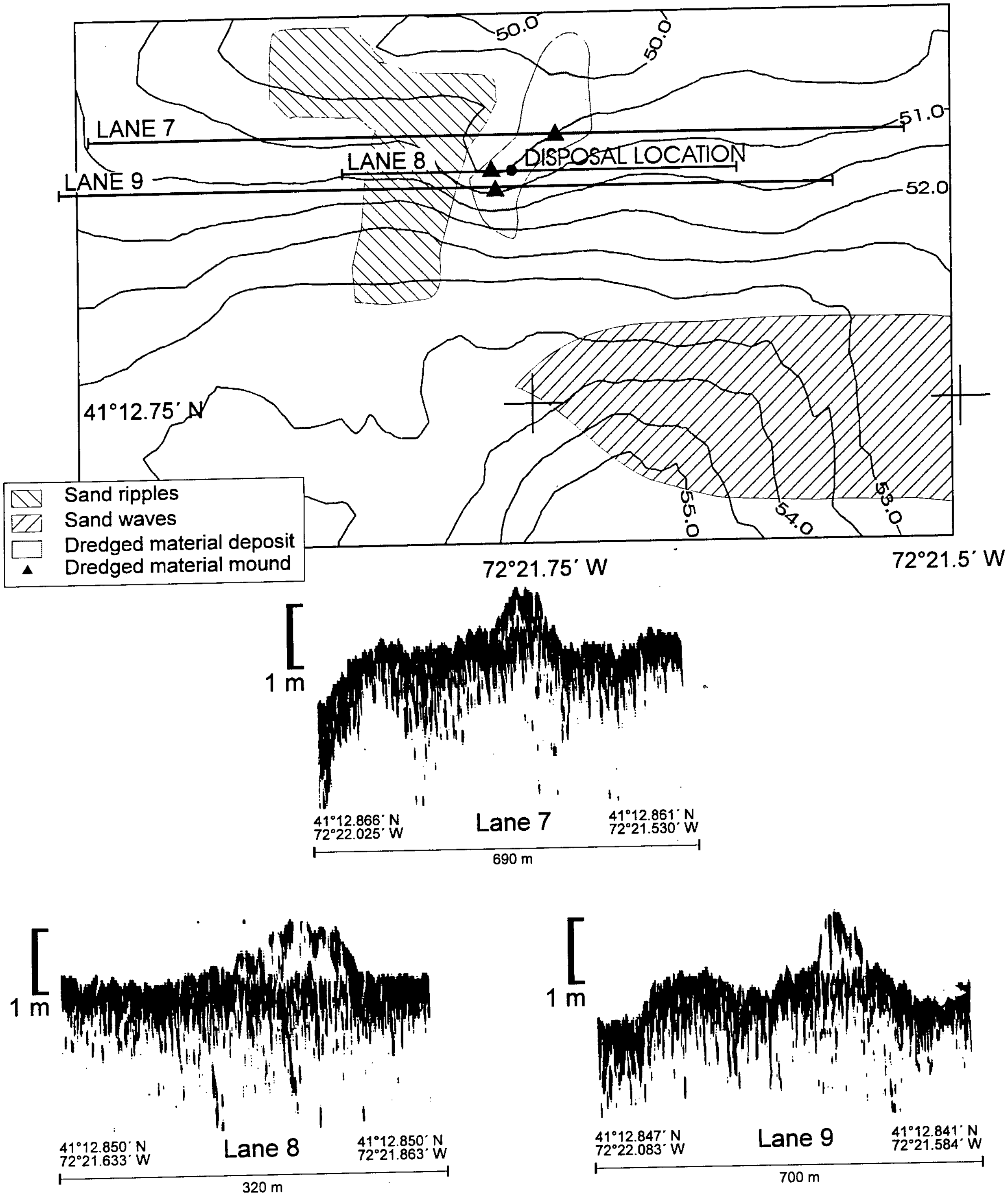

Figure 3-4. X-Star subbottom record showing dredged material mound at CSDS, July 1994

differentiate between the dredged material and the ambient bottom reflectors. However, a slight rise in the seafloor could be detected near the disposal location (Figure 3-5).

On the subbottom record, what appear to be sand ripples are located on the western flanks of the disposal mound (Figure 3-6). Their amplitude ranges from approximately 30 cm in lane 4 to less than 20 cm in lane 10. The larger ripples extend approximately 150 m along the slope northwest of the disposal location. Closer to the disposal location, the ripples are less than 20 cm in amplitude and are concentrated in a swath less than 100 m wide (Figure 3-7). Larger waves with amplitudes of approximately 50 cm are located on the slope of the depression in the southeast corner of the survey (Figure 3-7 and Figure 3-8).

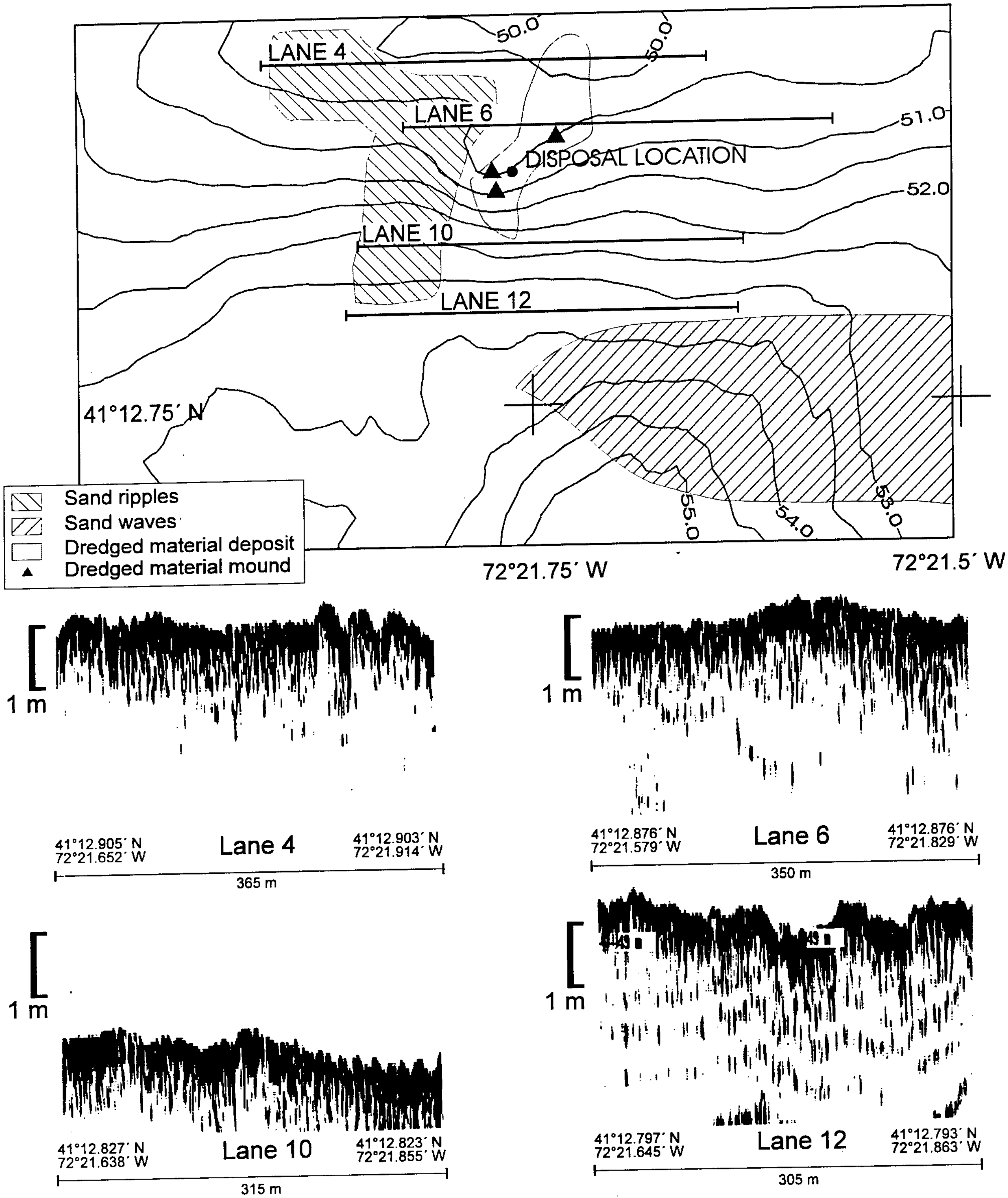

Figure 3-5. X-Star subbottom record north and south of CSDS, July 1994

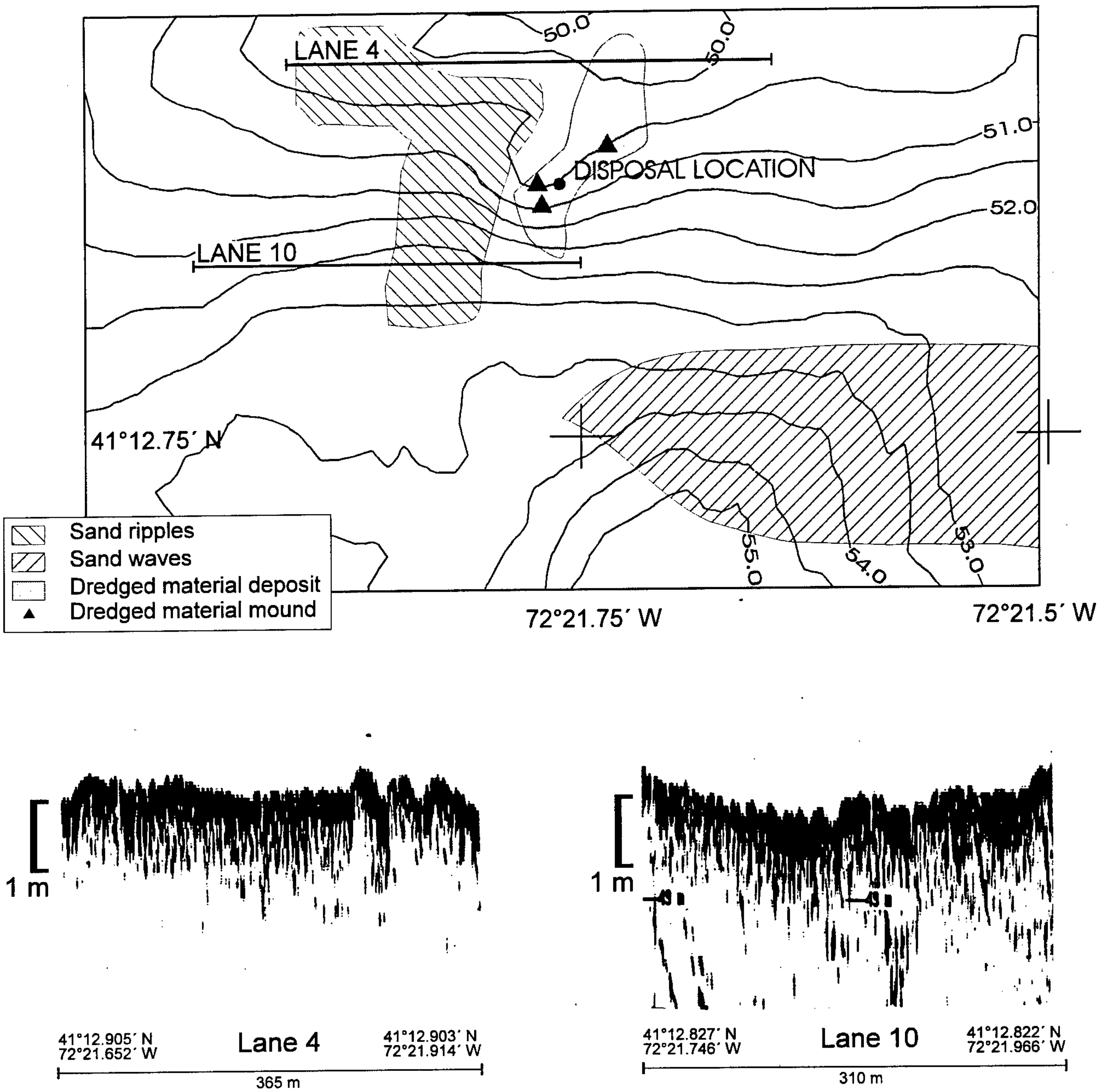

Figure 3-6. X-Star subbottom record at CSDS showing sand ripples on flanks of the dredged material deposit

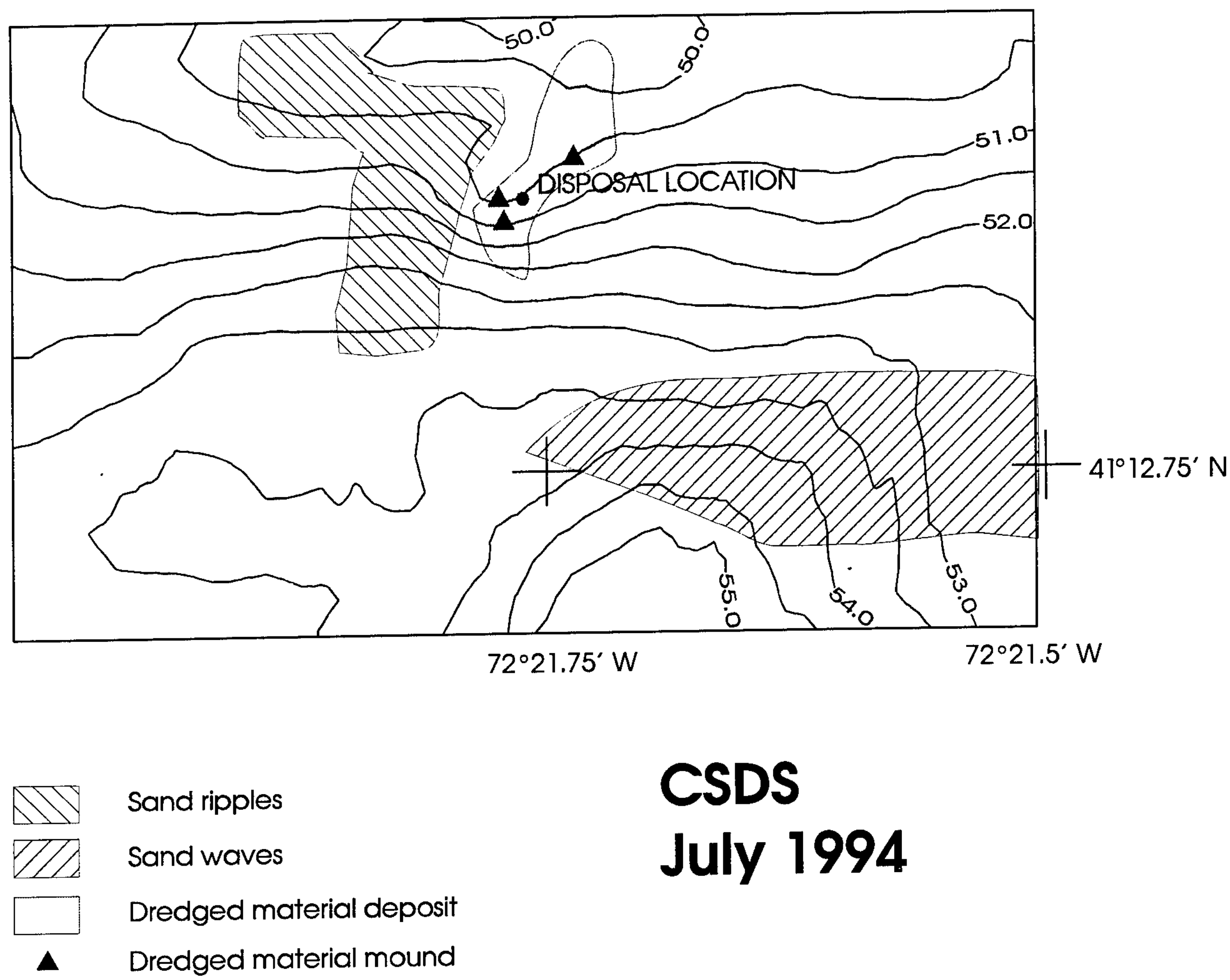

Figure 3-7. Areal distribution of seafloor characteristics noted on X-Star subbottom profile record, July 1994

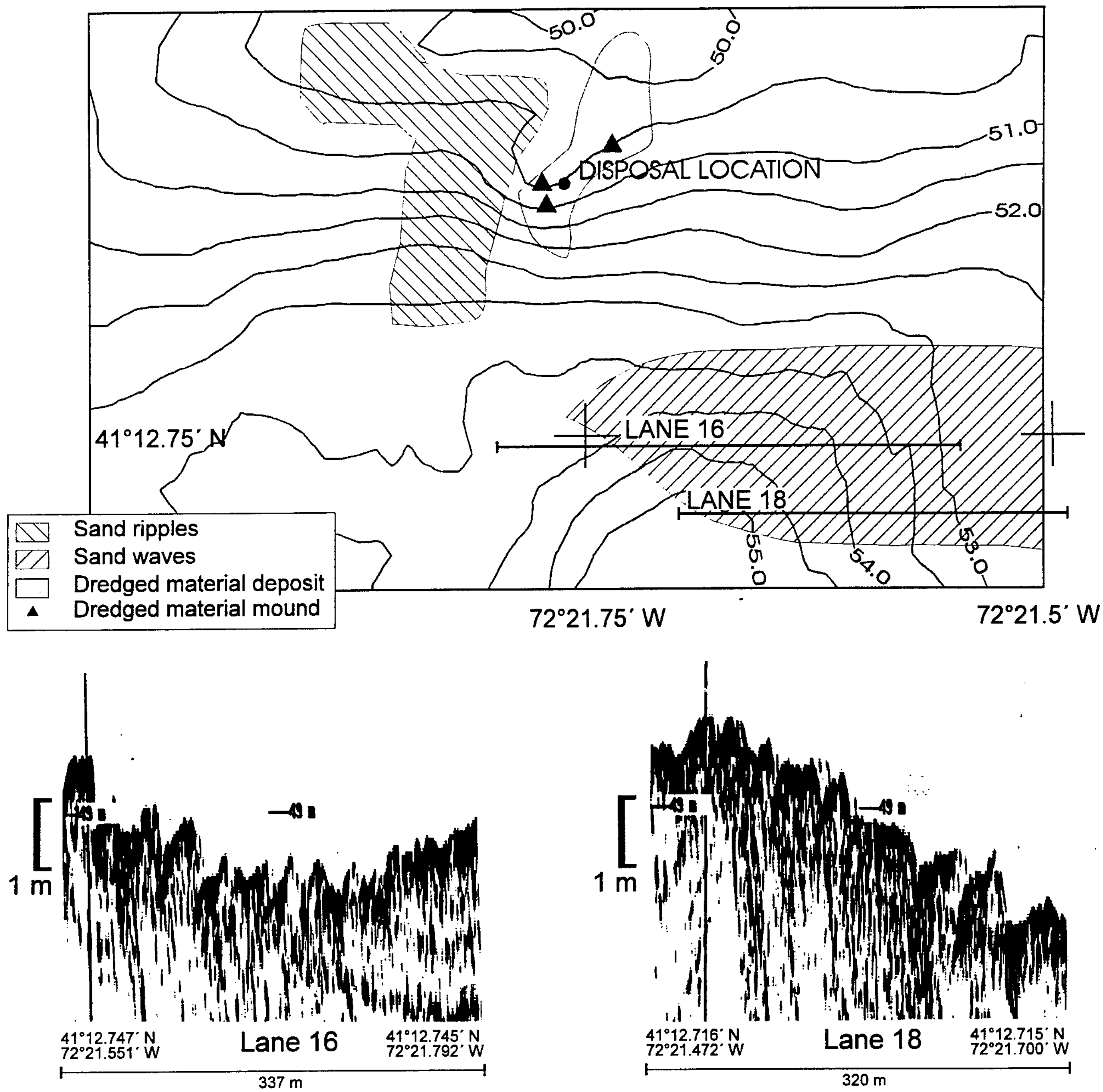

Figure 3-8. X-Star subbottom record at CSDS showing sand waves, July 1994

4.0 DISCUSSION

The bathymetric survey measured depth changes since the August 1992 survey. The X-Star subbottom survey, run concurrently, was conducted to map the extent or thickness of the fine-grained dredged material deposit observed in REMOTS® sediment-profile photographs in May and August 1992. The subbottom survey did show the location of the fine-grained dredged material deposit (in agreement with its location as detected in the bathymetric survey), as well as surface sediment features. It also showed a mound that was 1 m thick (height above the ambient bottom reflector).

Pre- and postdisposal bathymetric measurements in 1991 and in 1992 calculated the disposal mound height as 71 cm. The resolution of the bathymetric system can be up to ±25 cm. The results of the 1994 bathymetric survey showed a 25 cm increase in mound height. Again, this measured increase is at the outer limits for the resolution of the system. Comparing a 71 cm (±25 cm) disposal mound from the bathymetry results to a 1 m deposit on the subbottom record leads to two possibilities. The height of the mound may not have changed if the mound height at 71 cm and the thickness at 1 m are within the error range. If the 1 m thick deposit does represent an increase over the 71 cm measured in 1992, active bed transport may have transported ambient material to the peak of the mound.

The subbottom record also recorded the presence of ripples and waves. The form of these features, and the lack of any subbottom layering, indicate that they are most likely sand structures. The location of the sand ripples (<50 cm in height) is concentrated west of the disposal mound, corresponding to the valley seen in the bathymetry. This is in contrast to the 1992 REMOTS® sediment-profile survey where the ripples were observed in stations south of 41°12.750' N (Wiley 1996a). The shifting nature of these sand ripples is consistent with active bed transport documented in the area. The larger sediment waves (50 cm or more in height) were seen in the previous bathymetric studies of the area. The dynamic nature of these features is supported by their correspondence to areas of sediment accumulation (Figure 3-3).

5.0 CONCLUSIONS

CSDS, a high energy, dispersive dredged material disposal site, has traditionally been used for the disposal of both fine-grained and sandy dredged material. When sandy dredged material has been released at the center of the disposal site, it has been transported out of the site without forming a disposal mound. The detection of sand ripples and waves in the July 1994 subbottom survey indicates active bed transport at the site after disposal activity. Despite the presence of active bed transport, much of the fine-grained dredged material from North Cove that was released at the site during disposal season operations in 1991 and 1992 did form a persistent mound.

The formation of a dredged material mound at a dispersive disposal site allows the site to be managed in two ways. If close control or management of dredged material is desired, material should be released at a taut-wire moored buoy. This is likely to result in the accumulation of material, but it may also reduce the long-term site capacity. If close management is not desired, relatively small volumes of fine-grained material may be released at numerous discrete locations. This management approach would serve to prevent mound formation, enhance dispersal, and retain site capacity.

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